

PB-251 558

GUIDELINES FOR EVALUATING SUPPLEMENTARY
CONTROL SYSTEMS

Environmental Protection Agency
Research Triangle Park, North Carolina

February 1976

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TECHNICAL REPORT DATA (Please read instructions on the reverse before completing)		
1. REPORT NO. EPA-450/2-76-003	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Guidelines for Evaluating Supplementary Control Systems	5. REPORT DATE February 1976	
	6. PERFORMING ORGANIZATION CODE	
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.	
9. PERFORMING ORGANIZATION NAME AND ADDRESS Environmental Protection Agency Office of Air and Waste Management Office of Air Quality Planning and Standards Research Triangle Park, North Carolina 27711	10. PROGRAM ELEMENT NO. 2 AC 129	
	11. CONTRACT/GRANT NO.	
12. SPONSORING AGENCY NAME AND ADDRESS Same as above	13. TYPE OF REPORT AND PERIOD COVERED Final	
	14. SPONSORING AGENCY CODE	
15. SUPPLEMENTARY NOTES		
16. ABSTRACT Through a supplementary control system (SCS), SO ₂ emissions from a facility are temporarily curtailed when meteorological conditions conducive to high ambient SO ₂ concentrations exist or are anticipated. The purpose of the document is to provide guidance to facilities proposing to use SCS and to air pollution control agencies in their case-by-case evaluation of such systems to determine if the proposed systems will ensure attainment of air quality standards. The document provides specific guidance on (1) technical considerations with such systems, (2) meteorological conditions conducive to high ambient pollutant concentrations, (3) the application by the source to use an SCS, and (4) the development and implementation of such systems.		
17. KEY WORDS AND DOCUMENT ANALYSIS		
a. DESCRIPTORS Air Pollution Sulfur Dioxide Meteorology	b. IDENTIFIERS/OPEN ENDED TERMS Air Pollution Control Supplementary Control Systems	c. COSATI Field/Group
PRICES SUBJECT TO CHANGE		
18. DISTRIBUTION STATEMENT No restriction	19. SECURITY CLASS (This Report) Unclassified	21. NO. OF PAGES 70
	20. SECURITY CLASS (This page) Unclassified	22. PRICE \$ 00

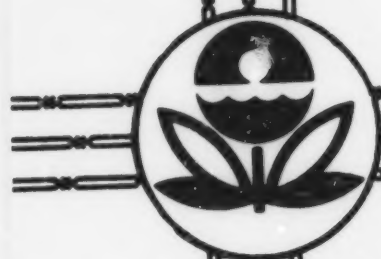
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PB 251 558

EPA-450/2-76-003
February 1976
(OAQPS No. 1.2-036)

GUIDELINE SERIES

**GUIDELINES
FOR EVALUATING
SUPPLEMENTARY CONTROL
SYSTEMS**



**U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711**

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EPA-450/2-76-003
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**GUIDELINES
FOR EVALUATING
SUPPLEMENTARY CONTROL
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Monitoring and Data Analysis Division

U. S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Air Quality Planning and Standards
Research Triangle Park, N.C. 27711

February 1976

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This document does not constitute a general endorsement of supplementary control systems as a control alternative. It is intended only to assist the responsible control agencies in those limited situations where legislation, EPA or the courts permit its use.

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Publication No. EPA-450/2-76-003

PREFACE

The purpose of this document is to provide guidance in evaluating the technical aspects of a supplementary control system (SCS). It is intended for use in conjunction with other key EPA documents concerned with SCS; particularly: EPA, September 1975; EPA, October 1975; EPA, February 18, 1976; and EPA, 1976a. This document should be referred to as early as possible in the development phase of a supplementary control system, although it should serve as a useful reference at any stage of SCS development.

The document is intended for use by the control agency and by the user or prospective user of an SCS. Section 1 presents an overview of SCS and discusses the responsibilities of the control agency and the SCS user. Section 2 describes the basic elements and functions of an SCS. Sections 3 through 5 provide guidance for the control agency in evaluating the SCS application, the SCS background study report, and the SCS operational manual submitted by the source. A brief discussion of the enforcement aspects of SCS is presented in Section 6. Detailed information on meteorological conditions conducive to high ground-level concentrations and a listing of the information that should be included in the SCS application and background study report are presented in two appendices.

It is assumed in these guidelines that a source using SCS will be required to accept legal responsibility for ambient SO_2 concentrations that occur within a designated liability area. The specific manner in which the source is to be considered responsible for air quality will be dictated by regulations applicable to the source.

Credit for the original version of this document is gratefully extended to the H.E. Cramer Company, Inc. (Contract No. 68-02-1392). Recent events regarding SCS have necessitated subsequent revisions. The document was prepared under the direction of Mr. Laurence Budney, EPA project officer, and under the general supervision of Mr. Herschel Slater, Chief, Source Receptor Analysis Branch, OAQPS, EPA. Figure A-3 of Appendix A is reproduced from "Recommended Guide for the Prediction of the Dispersion of Airborne Effluents, Second Edition" (1973) by permission of the American Society of Mechanical Engineers.

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DEFINITIONS OF KEY TERMS

The key terms used in this document are defined as follows:

Air Quality - Ground-level pollutant concentrations and their temporal and spatial distributions

Air Quality Monitoring Network - An array of continuous sampling stations that measure air quality. Ideally, these stations should be located at points where high ground-level concentrations are most likely to occur (see Section 4.1)

Air Quality Violation - The occurrence* of an ambient SO_2 concentration that exceeds an ambient air quality standard for SO_2 at any point within a designated liability area

Background Study - The collection and analysis of source, meteorological, and air quality data for the purpose of developing the SCS operational procedures (see Section 1.3).

Closed-Loop Mode of Operation - The SCS operational mode in which emission control decisions are based upon real-time measurements by the air quality monitoring network (see Section 2.2)

Compliance Schedule - A specification of the date or dates by which a source is required to comply with specific emission limitations

* In the case of the national ambient air quality standards for SO_2 , it is recommended that (1) running averages be used to determine the occurrence or non-occurrence of violations and (2) the concentrations specified for the 3-hour and 24-hour standards should not be exceeded more than one time per year in the designated liability area. This means that two or more non-overlapping excursions above either concentration should constitute "air quality violations," whether the excursions occur at the same or different monitors. It is important to recognize the distinction between this interpretation of the national standards for SCS applications and the recommended interpretation that has been commonly applied for AQCRs (EPA, August 1974).

and with requirements for SCS or other measures contained in an implementation plan. The compliance schedule may also include dates by which a source is required to achieve specified increments of progress toward such compliance (see Section 1.3)

Constant Emission Control (CEC) - The continuous limitation of SO₂ emissions from a stack through techniques such as stack gas cleaning or use of low sulfur fuel

Control Decision - The decision as to whether or not to curtail emissions. Emissions are curtailed whenever a curtailment criterion is met (see Section 2)

Controlled Emissions - The SO₂ emission rate resulting from the control decision

Control Strategy - The use of constant emission control in combination with the additional control measures necessary to assure the attainment and maintenance of air quality standards. Additional control measures include, but are not necessarily limited to, SCS, process changes, and reduction of low-level fugitive emissions

Curtailment Criteria - The criteria (predesignated threshold concentrations and meteorological conditions) upon which emission curtailment decisions are based (see Sections 2.1 and 2.2)

Data Storage - Synchronous records of meteorological data, emission data, dispersion model predictions, control

decisions and measured air quality. The records must be available for control agency review and for system upgrade (see Section 2.3)

Designated Liability Area (DLA) - The geographic area within which ambient air quality may be significantly affected by SO_2 emissions from the source and wherein the source accepts responsibility for maintaining ambient air quality standards for SO_2 (see Section 3.2)

Dispersion Model - A mathematical model that relates meteorological data, emission rates, other source data and terrain factors to air quality in the vicinity of the source

Effective Stack Height - The sum of (1) the physical stack height above grade and (2) the rise of the plume centerline after leaving the stack. The latter is due to the plume's initial vertical momentum and buoyancy

Emission Monitors - A system for the monitoring and recording of SO_2 emission rates (see Section 4.2)

Fugitive Emissions - Emissions that are not discharged through stacks, but escape to the atmosphere from plant buildings and vents because of leaks or the failure to capture emissions at all stages of production (see Appendix A)

Isolated Source - A source sufficiently remote from other significant sources such that it can and will accept responsibility for attaining and maintaining ambient air quality standards for SO_2 within a designated liability area (see Section 3.2)

National Ambient Air Quality Standards (NAAQS)- The primary NAAQS for SO_2 are a 24-hour average concentration of 365 micrograms per cubic meter (not to be exceeded more than once per year) and a maximum annual average concentration of 80 micrograms per cubic meter; the secondary NAAQS for SO_2 is a 3-hour concentration of 1300 micrograms per cubic meter (not to be exceeded more than once per year)

Open-Loop Mode of Operation - The SCS operational mode in which emission control decisions are based on calculations using the operating model in conjunction with either real-time or projected meteorological and emission data (see Section 2.1)

Operating Model - The key element in the open-loop mode of SCS operation. The model generates the information (viz., estimates of existing or predicted air quality or meteorological conditions) necessary for the open-loop control decision (see Sections 2.1 and 4.3)

Operational Manual - A detailed description of the SCS operational procedures and the curtailment criteria developed during the background study. The operational manual identifies the SCS responsibilities of specific company personnel (see Section 5)

Supplementary Control System (SCS) - A system by which SO_2 emissions are curtailed during periods when meteorological conditions conducive to ground-level concentrations in excess of ambient standards for SO_2 either exist or are anticipated (see Section 1.1)

System Upgrade - The continuous and systematic evaluation of the SCS elements and their interrelation in order to improve the reliability of the SCS in maintaining ambient standards for SO_2 ; the data-storage function is a prerequisite for fulfilling this SCS function (see Section 2.4)

Threshold Concentration - A measured or predicted short-term SO_2 concentration and/or rate of change of concentration that serves as an indicator of a potential violation of an ambient SO_2 standard. As such, it serves as an emission curtailment criterion

Time Delay - The time elapsed between the emission control decision and the time that the reduction in emissions begins to affect ambient air quality. This delay is equal to the sum of the time required to achieve the reduced emission level and the time required for the atmospheric transport of the reduced emissions to the point of the maximum ground-level concentration (see Section 2.1)

SECTION 1

INTRODUCTION

1.1 BACKGROUND

Through a supplementary control system (SCS), stack emissions of SO_2 are curtailed during periods when meteorological conditions conducive to ground-level concentrations in excess of ambient air quality standards for SO_2 exist or are anticipated. If certain prerequisites are met, as discussed in the following sections, an SCS may be effectively used by certain types of sources as a means to avoid the contravention of air quality standards. However, there are limitations inherent in supplementary control systems, particularly with regard to enforcement difficulties, the subjectivity inherent in such systems, and the fact that SCS relies upon emission dispersion rather than emission reduction. Due to those limitations, SCS will be permitted only in certain restricted situations where "achievable" constant emission control has been applied but is still inadequate to assure the attainment and maintenance of ambient standards for SO_2 . Regulations will dictate the specific circumstances under which SCS may be applied.

An important restriction on the use of SCS arises from the fact that the source should be sufficiently isolated from other large SO_2 sources such that measured SO_2 levels in the area affected by emissions from the source may be attributed to that source. If this condition is not satisfied, it may be exceedingly difficult for the control

agency to determine which source is responsible for any given contravention of an air quality standard. The geographic area in which ambient air quality may be significantly affected by the SO₂ emissions from a single, large stationary source, such as a nonferrous smelter or coal-fired electrical generating plant may range in extent from on the order of a hundred to a thousand square kilometers. It follows that SO₂ sources located close to other large stationary sources will not meet the isolated-source requirement for SCS.

The SCS concept of curtailing pollutant emissions during periods of adverse meteorological conditions (i.e., conditions conducive to excessively high ground-level concentrations) is not new. Historically, nonferrous smelter emissions of SO₂ were curtailed in the Salt Lake Valley of Utah during the 1920's and in the Columbia River Valley near Trail, British Columbia during the 1930's to reduce damage to vegetation. In recent years, considerable effort has been expended by certain large nonferrous smelters and coal-fired electrical generating plants to develop and operate supplementary control systems for the purpose of preventing ground-level SO₂ concentrations from exceeding ambient air quality standards. As a result of this effort, much has been learned about the design and operation of such systems as well as their effectiveness in maintaining air quality standards. This recent experience demonstrates that the use of SCS may substantially reduce the number of violations of the 3-hour and 24-hour national ambient SO₂ standards. At the same time, it is clear that the success of SCS in attaining and maintaining the NAAQS for SO₂ poses a number of highly complex technical and logistical problems.

The technical problems posed by SCS arise in part from the fact that many of the operational details of the system are affected by meteorological factors, topographic features and factors uniquely identified with the source in question. The meteorological factors include wind circulation patterns and atmospheric stability conditions controlling the transport and dispersion of stack discharges. Topographic features include prominent terrain elements that channel or block the normal airflow or induce vortices that affect the dispersion of stack plumes. Source factors include, in addition to the usual stack parameters (stack height, exit velocity, exit temperature, effluent composition and density, and pollutant discharge rate), fugitive emissions, plant layout of buildings and other structures that may produce aerodynamic effects on the effluent plume, and process details that determine the rate of emission curtailment. Other SCS technical problems include the selection and operation of an atmospheric dispersion model that accurately relates stack emissions to ambient air quality; the design and operation of automated air quality monitoring networks, meteorological measurement networks, and data-acquisition, -processing, -storage and -retrieval systems. The meteorological factors involved in SCS have only been partially quantified and, in most cases, the meteorological data required to design an SCS are not available. Furthermore, the number of professional meteorologists with extensive training and experience in SCS applications is limited.

At some sources, SCS will simply not be feasible due to insurmountable technical problems. For example, the source may not be technically capable of curtailing emissions fast enough (or to the

degree necessary) to protect ambient air quality. In other cases, due to the frequency of adverse dispersion conditions, an unacceptably high frequency of emission curtailments would be dictated to meet short-term air quality standards. In some cases, the long-term curtailment of plant production required to meet annual ambient standards would render operation of the facility economically unfeasible. A large SO₂ emitter in a poor-dispersion valley situation could easily fall into the latter category.

Logistical problems associated with SCS include decisions as to the total funds and personnel that should be committed to SCS; the allocation of funds and personnel to the various SCS functions; the specific types of equipment to be used for air quality monitoring and for network meteorological measurements; and the minimum time required for the design, procurement, installation, staffing and operational checkout of SCS. Experience to date indicates that the initial capital investment for a typical SCS is on the order of a half to one-million dollars; the annual SCS operating cost is approximately a third of a million dollars and approximately 6 to 8 full-time personnel are required to operate the SCS (2 to 4 meteorologists, 2 instrument specialists and 2 data-processing specialists); and the minimum time required for SCS design, procurement, installation and operational checkout varies from one to two years. The above estimates are very rough and are presented only to indicate the general magnitude of the SCS costs and the time required to implement SCS assuming no prior development or SCS operational experience.

1.2 CONTROL AGENCY RESPONSIBILITIES

Air pollution control agencies have four major areas of responsibility with regard to the use of SCS as a supplemental measure for limiting SO₂ emissions by a source within their jurisdiction. These areas are:

- Establishment of criteria that a source must meet in order to be considered eligible to use SCS
- Evaluation of SCS applications on a case-by-case basis to determine the justification for SCS and the feasibility of using SCS to attain and maintain ambient SO₂ standards.
- Surveillance of SCS operations and enforcement of applicable regulations
- Periodic review of SCS performance

Before a source can use SCS, it should submit the following documents to the responsible control agency for approval:

- A comprehensive statement (SCS application) justifying the need for SCS as a measure to limit SO₂ emissions and providing evidence that air quality standards could be attained through the use of SCS

- A background study report that documents the field monitoring program (see Section 1.3), describes the SCS, and demonstrates that ambient air quality standards will be attained through the use of SCS
- An operational manual for the SCS containing a complete description of all SCS components, the procedures to be used in operating and maintaining the SCS, the specific steps to be followed in curtailing emissions, and the specific criteria upon which curtailment decisions are based

The above documents are discussed in Sections 3, 4, 5 and Appendix B. It is the responsibility of the control agency to evaluate those documents to determine if SCS is justified and if the proposed system is a feasible means for meeting air quality standards.

In order to fulfill the requirements for SCS surveillance and enforcement, the responsible control agency should have access to all SCS operational data possessed by the source and should be authorized to inspect and check the performance of all equipment and monitors associated with the SCS. In addition, regulations may require the control agency to ascertain whether or not the curtailment procedures specified in the SCS operational manual are being followed. The control agency activities and responsibilities with respect to SCS surveillance and enforcement are clearly much more extensive and more costly than those required for sources that rely solely upon constant emission control. If appropriate, the control agency should evaluate

the possibility of recovering the additional costs involved in SCS surveillance and enforcement by imposing fees on each source using SCS.

1.3 SEQUENCE OF STEPS FOR IMPLEMENTING SUPPLEMENTARY CONTROL SYSTEMS

Table 1-1 lists the approximate sequence of actions to be taken by the source and the responsible control agency in the implementation of an SCS. It should be noted that the sequence in Table 1-1 is intended only as an example. The exact sequence of steps in each case will be dictated by regulations and will be a function of circumstances.

An SO₂ source considering SCS as a control measure must first determine whether or not SCS is justified in its particular case. Regulations will specify the criteria upon which that determination is to be based.

Technical feasibility must also be determined before the source submits its application (Table 1-1, Step 1) for permission to use SCS. (Also see Section 3 and Appendix B). If feasibility is anticipated, a tentative SCS design concept (including a proposed designated liability area) should then be developed, based upon an analysis of existing source, meteorological, air quality, and other relevant data. It is recommended that such data be supplemented by a pollutant dispersion modeling analysis. In cases where the source has already had experience with some form of SCS, the formulation of an SCS design concept may be relatively straightforward. In any case, SCS feasibility must be anticipated and a tentative SCS concept should be developed before the source submits an application to use such a system.

TABLE 1-1

EXAMPLE SEQUENCE OF STEPS* FOR SUPPLEMENTARY CONTROL
SYSTEM DESIGN, DEVELOPMENT, AND IMPLEMENTATION

- | | |
|---|--|
| 1 | <p><u>Source Submits Application to use SCS, which:</u></p> <ul style="list-style-type: none"> 1.1 Demonstrates that SCS is justified. (Regulations may specify the criteria upon which justification is to be based.) 1.2 Demonstrates that SCS is a feasible control measure at the source in question. 1.3 Presents a tentative SCS design that will ensure the attainment and maintenance of ambient air quality standards for SO₂. 1.4 Proposes a designated liability area. 1.5 Proposes a plan for developing and implementing the SCS. |
| 2 | <p><u>SCS Compliance Schedule:</u></p> <ul style="list-style-type: none"> 2.1 Submit final plan for developing and implementing the SCS. 2.2 Issue purchase orders, let contracts, etc., for SCS equipment required under the plan and personnel required to operate the system. 2.3 Complete installation and testing of SCS equipment and orientation of SCS personnel. 2.4 Complete a <u>field monitoring program</u>, during which concurrent source, meteorological, and air quality data are collected. 2.5 Submit a <u>background study report</u> that documents the field monitoring program, describes the SCS in detail, and demonstrates that ambient standards for SO₂ will be attained and maintained. 2.6 Submit the <u>SCS operational manual</u>, which describes the SCS including all of the operational procedures. 2.7 The Source becomes responsible for maintenance of ambient standards for SO₂ within the designated liability area. |

*The timing of public hearings and the promulgation of regulations for SCS will vary, depending upon circumstances. Therefore, those two items are not included in this table.

Upon control agency approval of the application, a compliance schedule (Table 1-1, Step 2) will be established. A major portion of the schedule involves an SCS "background study," which basically involves the collection and analysis of source, meteorological and air quality data, including consideration of other relevant factors such as other sources in the area and topography. The objective of the background study is to develop the initial SCS design concept into a working system. The basic functions and elements of a supplementary control system are discussed in Section 2.

An integral part of the background study is the field monitoring program. The principal objective of the monitoring program is to collect adequate amounts of concurrent source, meteorological and air quality data, and any other relevant data, such that (1) the meteorological conditions during which emission curtailment will be required can be identified, (2) the corresponding effect of those conditions on SO₂ dispersion from the source can be determined and (3) the timing and degree of emission curtailment that will be required during each condition can be estimated. To make such determinations, a substantial quantity of data is obviously required. The shortest period during which a meaningful field monitoring program can be conducted is on the order of 120 days. Also, the 120-day period is adequate only if it occurs during the time of year when the worst dispersion conditions are likely to occur. If the latter condition is not met, a period of 240 to 360 days is preferable.

The background study report (Step 5 of the compliance schedule) is drafted and submitted to the control agency for approval after a

working SCS has been developed. (Also see Section 4 and Appendix B)

The working system should contain the basic functions and elements discussed in Section 2. The background study report should:

- Document the field monitoring program.
- Describe the meteorological conditions during which emission curtailment will be required.
- Describe in detail the functions and elements of the SCS.
- Demonstrate that the system, in conjunction with any other control measures employed by the source, will result in the attainment and maintenance of ambient air standards for SO₂ in the designated liability area.

The operational manual (Step 6 of the compliance schedule) is submitted to the control agency for approval following the background study. It is largely based upon the background study report, and is similar to the latter in that it also includes a description of the SCS (see Section 5). However, it goes further than the background study report in that it specifies the SCS operational procedures in considerable detail, including procedures to be followed when specific curtailment criteria are met, and it describes the responsibilities of specific company personnel. Also, from an enforcement standpoint (see Section 6),

and unless regulations specify otherwise, the SCS user will be required to operate the SCS in strict accordance with the approved operational manual.

SECTION 2

BASIC FUNCTIONS AND ELEMENTS OF A SUPPLEMENTARY CONTROL SYSTEM

The operation of an SCS comprises four basic functions:

- Open-loop control of stack emissions
- Closed-loop control of stack emissions
- Data storage
- System upgrade

2.1 OPEN-LOOP CONTROL OF STACK EMISSIONS

Open-loop control is defined herein as the SCS function whereby an "operating model" (see Figure 2-1) is used to determine when emission curtailment is dictated. (The concept of open-loop control must be distinguished from closed-loop control, discussed in the following section, which is based solely upon monitored air quality.) The operating model, utilizing input source and meteorological data, will generally supply the following type of information:

1. Estimates of existing or predicted air quality within the geographic area affected by emissions from the source.

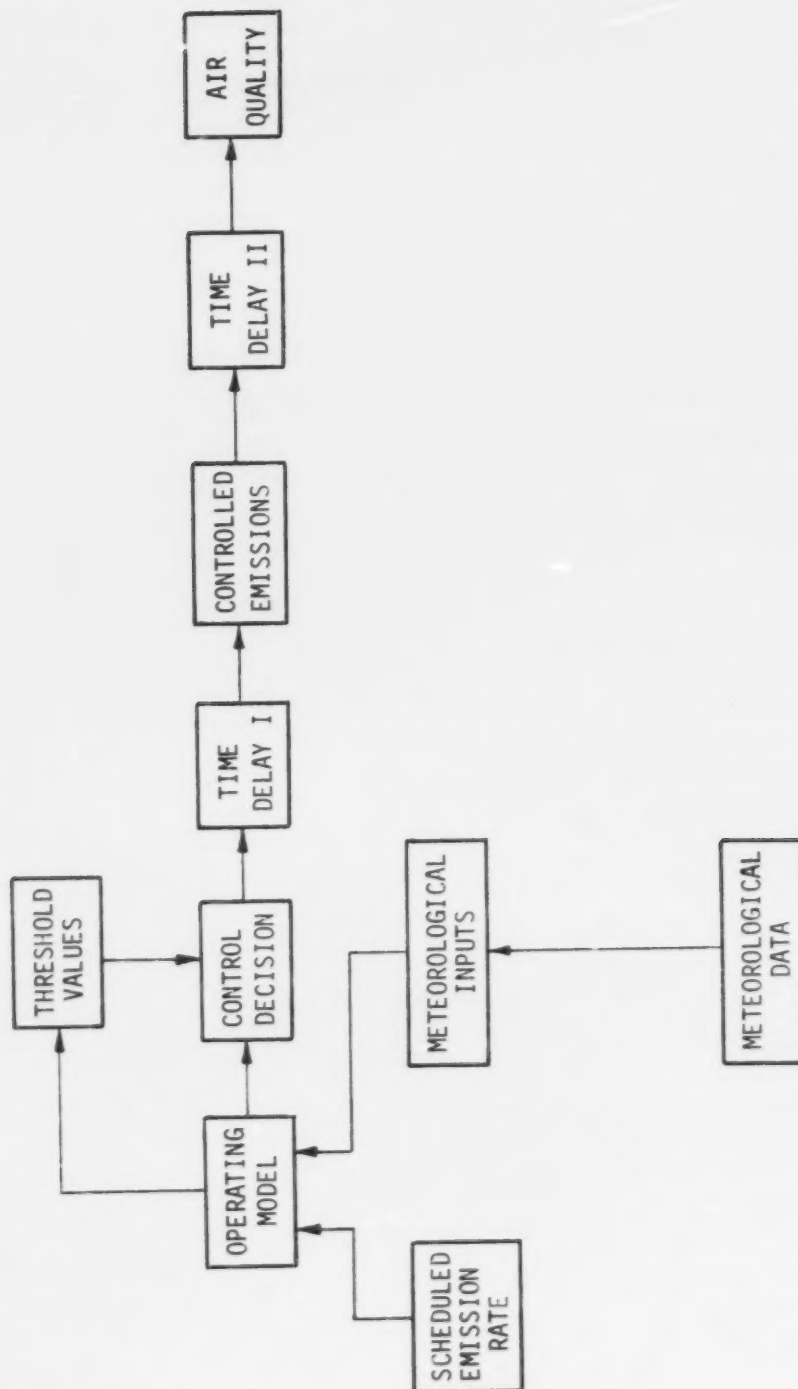


Figure 2-1. Diagram of the elements and information flow for open-loop SCS operation.

2. A determination of whether or not meteorological conditions conducive to excessive ambient pollutant concentrations exist or are anticipated.

The air quality estimates provided in (1) are compared to specified concentration "threshold" values. If the estimates indicate that a threshold value is exceeded or is expected to be exceeded, emission curtailment is dictated. Thus, the threshold concentration values serve as open-loop emission curtailment criteria.

Additional open-loop curtailment criteria may be in the form of specified "critical" meteorological conditions, which are known to be conducive to excessive ambient pollutant concentrations (see item 2 above). When a critical meteorological condition is observed or anticipated, emissions are curtailed accordingly.

Appropriate emission curtailment criteria can best be identified through the experience gained during development or operation of the SCS. Much relevant experience should be gained during the SCS background study, which is discussed in Section 4. For example, through the background study, appropriate safety factors can be identified and incorporated into the threshold concentrations; i.e., the threshold concentrations should be established at "safe" levels below the air quality standards of concern. The accuracy of the operating model in estimating existing and future air quality will be a key factor in determining the magnitude of the safety factors.

In general, open-loop control will comprise an essential component of supplementary control systems. That is apparent for two important

reasons. First, through the operating model, air quality can be estimated at a large number of locations compared to the limited number of locations served by an air quality monitoring network. Thus, air quality can be estimated at many locations between the monitor sites, providing air quality information that would otherwise not be available. Such air quality information is important (1) to the SCS user for the operational aspects of the system and (2) to the control agency for enforcement purposes.

A second major asset of open-loop control arises from the fact that advance warning will often be required by the SCS operator in order to prevent an air quality standard from being exceeded. Such warning may be provided by the open-loop mode if the system is designed to generate air quality forecasts; e.g., through application of a dispersion model that utilizes input source data and predicted meteorological conditions. Advance warning of unfavorable dispersion conditions is necessary because of two time delays that come into play whenever a decision is made to curtail emissions. The time delays are defined here and are indicated in Figures 2-1, 2-2, and 2-4:

Time delay I - the time required to effect a specified percentage curtailment in SO_2 stack emissions through process changes or other means

Time delay II - the time required for a curtailment in emissions to have a significant effect on maximum ground-level concentrations; this time delay is determined by existing air quality and meteorological conditions.

Depending upon circumstances, time delays I and II can be as long as several hours.

2.2 CLOSED-LOOP CONTROL OF STACK EMISSIONS

The concept of closed-loop control is less complex than that of open-loop control. Emission curtailment decisions in the closed-loop mode of SCS operation are simply a function of real-time monitored air quality. When the monitoring network indicates that ambient concentrations exceed specified threshold values, or that the rate of increase of concentrations exceeds a specified rate, the emissions are reduced accordingly. These threshold values may be referred to as the closed-loop emission curtailment criteria.

The value of closed-loop control lies in the fact that it offers real-time air quality information. Thus, when the open-loop mode fails to recognize or predict an air quality problem, the closed-loop mode may offer the SCS operator enough information so that he will be aware of the problem and be in a position to take corrective action.

In noting the value of closed-loop control, however, serious shortcomings of that mode of SCS operation also become apparent:

1. A fixed monitoring network provides air quality information only at a limited number of discrete locations. Peak ground-level concentrations will often occur in areas other than where the monitors are located.

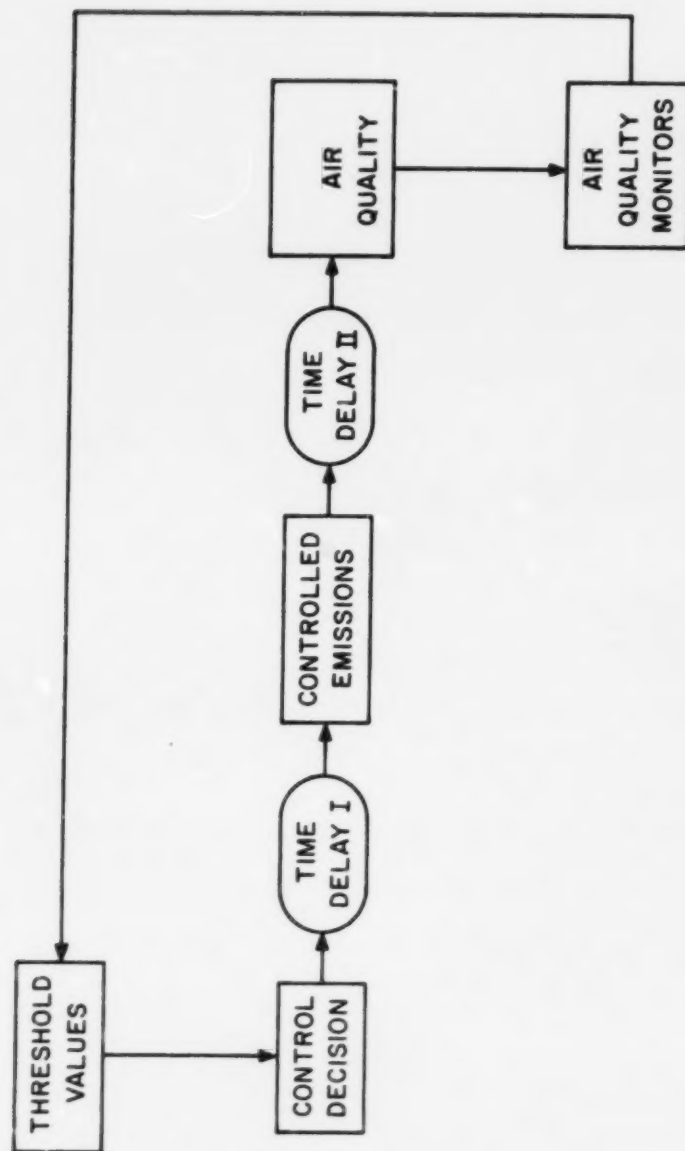


FIGURE 2-2. Diagram of the elements and information flow for closed-loop SCS operation.

2. A monitoring network provides little or no warning of air quality problems. By the time high concentrations are detected, it may be too late to prevent an air quality violation. (See the discussion of Time Delays I and II in the preceding section.)

Due to those limitations, the closed-loop mode will usually serve primarily as a back-up or supplement to open-loop control. Open-loop control should normally constitute the primary basis for the emission curtailment decisions.

2.3 THE DATA STORAGE FUNCTION

The SCS data-storage function shown schematically in Figure 2-3 is intended to provide for archiving, in a convenient and readily accessible form, detailed records of SCS operation and performance. It is particularly important that records are kept on every parameter used in the decisions to curtail and resume emissions. These records will generally include, and are not necessarily limited to, chronological tabulations and summaries of:

- Meteorological data
- Meteorological inputs used in the operating model (including meteorological forecasts)
- Operating model calculations

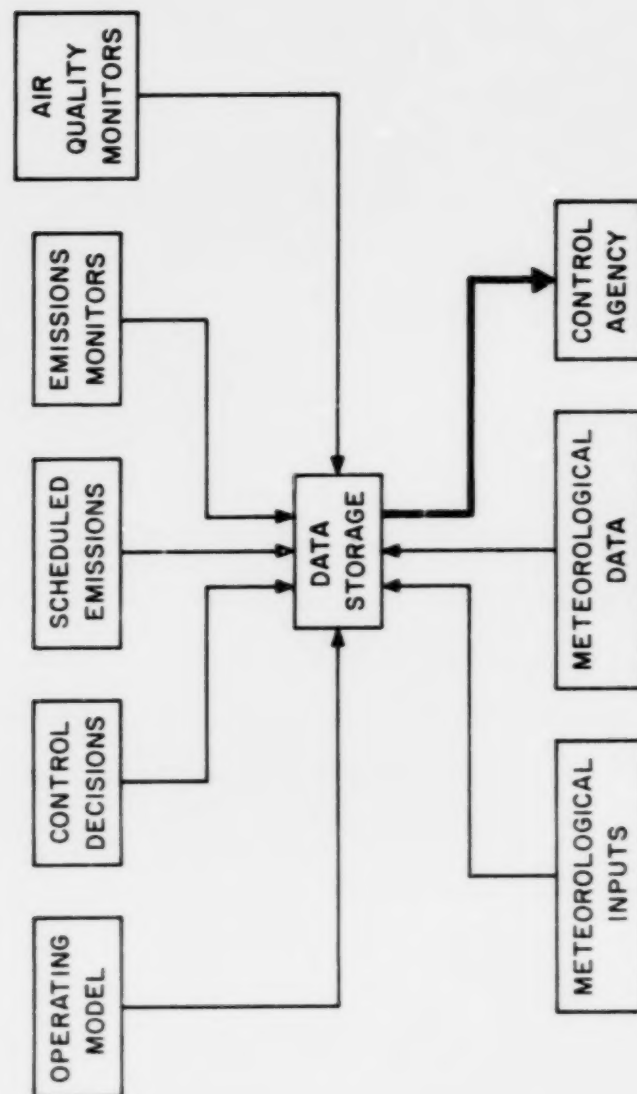


FIGURE 2-3. Diagram of the elements and information flow for the SCS data-storage function.

- Scheduled emissions
- Emission monitoring data
- Air quality monitoring data
- Control decisions
- System malfunctions, calibrations of system components, and adjustments or replacements of system components

Detailed records of this type form the basis of reports on SCS performance and operation required by the control agency for SCS evaluation and enforcement. These detailed records are also needed by the SCS operator to implement the fourth SCS function - system upgrade.

2.4 THE SYSTEM UPGRADE FUNCTION

The system upgrade function has as its purpose the refinement and improvement of SCS operation through a periodic analysis of SCS operation. It is expected that the maximum effort and activity in system upgrade will be required during the first year of SCS operation. As a result of the experience gained during the first year of actual operations, and using the detailed records available from data storage, it should be possible to make a detailed assessment of the adequacy of each of the SCS elements and functions and to effect many of the changes necessary to optimize SCS performance. A system upgrading

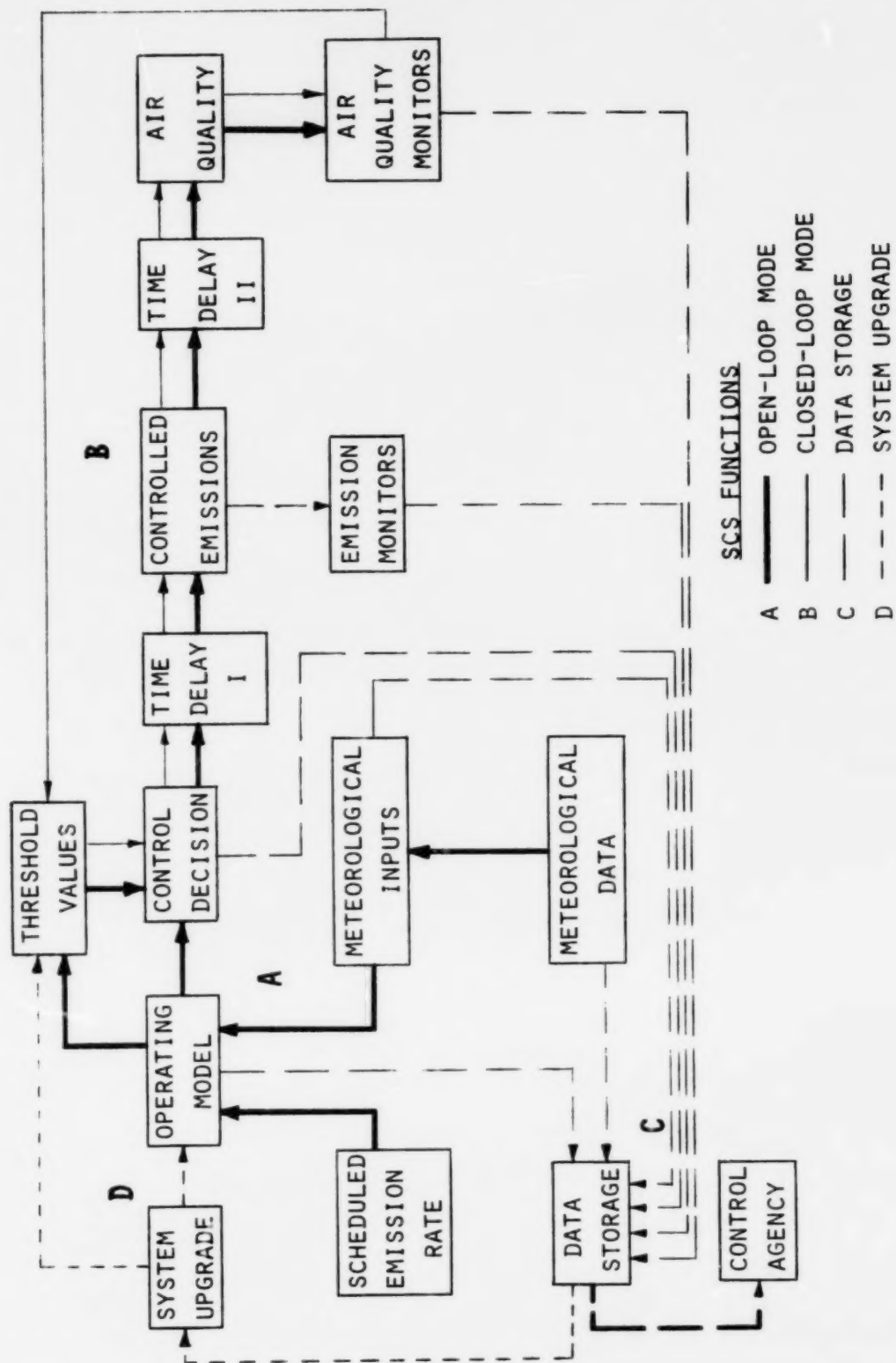


FIGURE 2-4. Composite diagram of Supplementary Control System functions and elements.

program should continue on a permanent basis, even if ambient SO₂ standards are maintained, to maximize the possibility of effectively dealing with the various contingencies that can arise during the operation of such systems. Additional guidance on SCS reliability analysis and upgrading is presented in Section 4 and "A Technique for Supplementary Control System Reliability Analysis and Upgrading" (EPA, 1976a).

Figure 2-4 is a composite diagram of all SCS functions and elements, including system upgrade. The lines in Figure 2-4 have different markings to assist in identifying the elements involved in each of the four SCS functions.

SECTION 3

APPLICATION TO USE A SUPPLEMENTARY CONTROL SYSTEM

A facility proposing to use SCS should submit to the responsible control agency an application that (1) justifies the proposed use of SCS by demonstrating that it is needed in order for ambient SO₂ standards to be met in the vicinity of the source, (2) proposes an SCS design concept and (3) provides evidence that use of the proposed system would result in the attainment of the ambient standards. A suggested list of the information that should be included in the SCS application is presented in Appendix B, Section B.1. Specific requirements for the application may be dictated by regulations applicable to the source.

This section discusses factors that should be accounted for by the control agency in evaluating the technical aspects of the SCS, as proposed in the application.

3.1 DESCRIPTION OF THE FACILITY

The SCS application should include a description of the type, location and age of the facility as well as the processes, equipment, raw materials and/or fuels used by the facility. Stack data and estimated emission data under the proposed SCS should be included to permit the control agency to estimate the impact of the source's emissions on air quality. In addition, plant layout and topographic information should be provided to permit an assessment of the possibility

of adverse effects of terrain features and buildings on effluent plume dispersion (see Appendix A).

The application should also include a description of the source's current and projected constant emission control techniques and the corresponding emission rates. Regulations applicable to the source will specify constant emission control requirements. Fugitive emissions, if any, and the source's plans to control fugitive emissions should also be described.

3.2 QUALIFICATION AS AN ISOLATED SOURCE

In order to use SCS, a source should qualify as an isolated source - that is, one that is sufficiently remote from other large sources such that it can and will accept legal responsibility for attaining and maintaining the ambient standards for SO_2 within a designated liability area (DLA). The DLA defines the specific geographic area surrounding the source in which the ambient air quality may be significantly affected by emissions from the source. In the application to use SCS, the source should propose a designated liability area.

Determination of the Designated Liability Area (DLA)

It is suggested that ambient monitoring and pollutant dispersion modeling be used to define the DLA. Dispersion modeling techniques are presented in "Reviewing New Stationary Sources" (EPA, 1976c). In the absence of dispersion modeling, a first approximation to the

DLA may be designated as the circular region defined by the minimum radius given in Table 3-1 for the applicable source emission rate. Table 3-1 is intended only for approximate initial estimates of the DLA, and will be conservative for some sources. Short-term and long-term dispersion modeling, on-site observation, and experience during the field monitoring program, will provide the best insight into how the DLA can be tailored to the source in question.

Conflicting Sources

The application should include the location, number and relevant emissions inventories of current or proposed sources in the vicinity of the source proposing to use SCS if the sources are likely to influence the ambient air quality of the proposed DLA. In some exceptional cases, if regulations permit, the control agency may decide that two or more SCS users may share a DLA. In such cases, the basis for sharing liability for an air quality violation should be established a priori. For SCS to be enforceable, use of SCS by sources located in or near large urban areas is not recommended because of the difficulty in unequivocally determining the relative contribution to ambient air quality of the non-SCS sources and because the SCS cannot normally be expected to anticipate the impact on ambient air quality of sources beyond its control.

TABLE 3-1

A FIRST APPROXIMATION TO MINIMUM RADII DEFINING THE
LIMITS OF THE DESIGNATED LIABILITY AREA

SO ₂ Emission Rate*		Radius	
Tons Per Hour	Grams Per Sec.	Statute Miles	Kilometers
16 or less	4,000 or less	7	11
24	6,000	10	16
32	8,000	15	24
40	10,000	20	32
48 or more	12,000 or more	25	40

*Full-production emission rate without considering any constant emission controls employed by the facility.

Existing Ambient Air Quality

A source proposing to use SCS should provide all available data on the frequency and severity of recent SO_2 concentrations in excess of the ambient standards, together with supporting emission and meteorological data, if available. If the air quality data are not adequate to make such a determination, they should be supplemented by dispersion modeling results. On the basis of these data, the source should be able to provide a preliminary assessment of the meteorological conditions during which ground-level concentrations may endanger the ambient air quality standards.

That preliminary analysis should provide the background for the source's initial plan for the development and implementation of an operational SCS (see Table 1-1, Step 1.5). More information on the initial plan for SCS development is presented in Appendix B, Section B.1.

3.3 EFFECTIVENESS OF THE PROPOSED SUPPLEMENTARY CONTROL SYSTEM

The application should include estimates of the emission reduction required to meet the ambient standards for SO_2 , emission reduction attainable with any constant emission control techniques that will be used, and the emission reduction attainable with SCS. The source should provide evidence that emission rate curtailments attainable with SCS will ensure compliance with ambient standards at all points within the proposed designated liability area. These calculations should take

into account estimated effects of the time delay (see Section 2.1) between the time of the control decision and the time that the reduced emissions begin to affect ambient air quality. The advance warning time of adverse atmospheric dispersion conditions provided by the SCS must be compatible with the time delays inherent in the system.

SECTION 4

EVALUATION OF THE BACKGROUND STUDY

Upon control agency approval of the SCS application, the prospective SCS user will generally be required to conduct a background study (see Section 1.3). The study will be largely based upon a field measurement program during which concurrent source, meteorological and air quality data are collected. The data are then analyzed for the purpose of developing the SCS operational procedures.

Upon completion of the background study, the source should submit to the control agency a report on the study. The topics that should be addressed in the SCS background study are listed in Appendix B. In reviewing this report, the control agency should determine whether the SCS includes the minimum elements (air quality monitoring network, emission monitoring capability, operating model, meteorological network, meteorological forecasting capability, data storage system, and system upgrading procedures) and whether the operational interrelation of these elements developed during the study is likely to ensure compliance with ambient SO_2 standards. These elements are discussed below.

4.1 AIR QUALITY MONITORING NETWORK

The air quality monitoring network provides the basic data required to establish the degree of compliance with ambient standards. In addition, the network is a key element in the development of both the closed- and open-loop modes of SCS operation (see Section 2),

and is the central element of the closed-loop mode. Thus, the source should demonstrate that it has made a good-faith effort to assure that the monitors are at or near the points of expected maximum SO_2 concentrations. To assist in the siting of monitors, it is strongly recommended that dispersion modeling and mobile or portable air quality monitors be utilized. In addition, it is recommended that some monitors be sited in population centers and sensitive crop areas that may be subject to significant (albeit not necessarily the highest) ambient SO_2 concentrations.

The monitoring network must be designed to be capable of the routine real-time measurement of maximum SO_2 concentrations for the averaging times of the applicable ambient standards. In the absence of significant terrain or building-wake effects, the short-term maximums produced by tall stack emissions will occur at radial distances from the stack that vary from about 10 to 30 stack heights. The short-term maximums resulting from low-level fugitive emissions will occur in close proximity to the source and should be monitored near the source (e.g., at the property boundaries). The above estimates of the distances from the source at which short-term maximums are most likely to occur serve to define the radial distances at which air quality monitoring stations should generally be located. The angular sectors within which the short-term maximums will occur can only be defined from a knowledge of the joint frequency distributions of wind speed, wind direction and stability applicable to a particular site.

Generalized criteria for determining the number and location of air quality monitoring stations required by an SCS have not been

established. The maximum number of air quality monitoring stations is ultimately set, on a case-by-case basis, by economic and logistics factors. The optimum number of monitoring stations will therefore probably lie between this upper limit and the minimum number of stations that will ensure compliance with ambient standards at the lowest acceptable level of risk that violations of the short-term standards will not be detected. Based on the experience to date with SCS at nonferrous smelters and large coal-fired power plants, SCS air quality monitoring networks should include at least 10 monitors, and two or three times that number will be appropriate in certain cases.

Experience gained by the applicant during the background study will often present the first opportunity to assess the adequacy of the initial network design with respect to the number and location of monitors. Thus, a substantial degree of flexibility should be maintained with respect to the siting of air quality monitors, at least until well into the background study. The use of mobile air quality sampling techniques during the study, in conjunction with the operation of fixed monitors and dispersion analyses accounting for the factors addressed in Appendix A, will be the best way of determining any required adjustments.

Additional guidance on air quality monitor siting in the vicinity of a point source is provided in "Guidance for Air Quality Monitoring in the Vicinity of Large Point Sources" (EPA, 1976b).

4.2 EMISSION MONITORING AND PREDICTION CAPABILITY

Emission monitoring provides the basic data required by the control agency to establish compliance with the SCS operational manual and with any other emission limitation requirements applicable to the source. In an operational SCS, emission rates must be determined by continuous in-stack monitoring or by appropriate process calculations if they have the same degree of reliability as the in-stack monitoring rates. It is recommended that control agencies require that both methods be routinely used. The process calculations will provide an important overall check on the in-stack monitoring measurements. Also, in the event that the in-stack monitoring system fails, process calculations afford the only means of obtaining emission rates during the period required to take corrective action and to place the in-stack monitoring system back in operation. It is essential that the procedures for process calculations and the relationship of these calculations to the stack measurements be firmly established.

The background study must clearly demonstrate that the source has the ability to accurately predict emission rates that will occur during normal operations and during the various degrees of proposed emission curtailment. Thus, during the background study, the source should have used emission measurements or process calculations to determine (1) the response time for emission reductions and (2) the degree of uncertainty in predicted emission rates.

4.3 OPERATING MODEL

The operating model is the single most important component in the open-loop operational mode of an SCS (Section 2.1). The basic SCS concept requires that the operating model be capable of relating emission and meteorological data to short-term maximum ground-level concentrations. It is on the basis of the operating model that open-loop emission control decisions are made. Since the closed-loop mode of SCS operation often cannot be relied upon to allow enough lead time to preclude violations of short-term air quality standards, the value of the operating model can readily be appreciated.

Development of an SCS operating model for a particular facility requires a careful analysis of source factors, climatological records, topographic factors, and air quality data. Because each source will be characterized by a unique combination of factors, the development of an operating model must be conducted on a case-by-case basis.

The first phase in the development of an operating model will usually be to utilize existing data in conjunction with an elementary dispersion model (e.g., Turner, 1970; Carpenter, *et al.*, 1971; and EPA, 1976c) to obtain initial estimates of an appropriate DLA and to formulate initial SCS curtailment criteria. Much of the first phase should normally be accomplished before the source submits its application to use SCS. It is during the background study, and during subsequent system upgrading, that any complicating factors peculiar to the source and to effluent dispersion from the source should be assessed in the requisite detail to ensure that they can be adequately accounted for in the operating model. Adequate incorporation of those factors is the

time-consuming step in the development of an operating model, and it may take a year or longer before all such effects can be adequately accounted for.

Because of the uncertainties involved in using an operating model to anticipate high ambient concentrations, a reasonable margin of safety in predicted concentrations should be built into the model to ensure adequate protection of air quality. The adequacy of the model should be demonstrated in the background study report by a comparison of expected and observed maximum ground-level concentrations obtained during the background study.

Finally, it should be noted that the guidance of an experienced meteorologist with a background in dispersion modeling is clearly required during all phases of development of the operating model.

4.4 METEOROLOGICAL NETWORK

Utilization of the dispersion model during the normal open-loop operational mode of an SCS requires that current emission and meteorological data be available for input to the model. The meteorological data must be representative of the wind and temperature structures controlling the downwind transport and dispersion of the stack discharge. In essence, this requires knowledge of the vertical profiles of wind speed, wind direction and air temperature through an atmospheric layer that extends from ground level to elevations above the plume stabilization height. Such measurements

are difficult and expensive and clearly cannot be obtained at the higher elevations from fixed sensors. The maximum measurement height that can generally be attained by fixed-point methods is probably given by the stack height since it may be possible to use the stack as a measurement platform, and since towers more than 200 to 300 feet in height are generally economically infeasible. The SCS meteorological measurement problem is additionally complicated by the fact that the dispersion-model calculations often require current hourly mean values that are updated hourly. The required hourly measurements can be provided by fixed sensors for the height interval between ground level and the top of the stack. A minimum of two measurement levels is required--one located near ground level (in a location not significantly affected by downwash or other types of airflow distortion due to plant buildings or other roughness elements) and one located at the height of the top of the stack. The low-level wind measurements are needed to predict the transport and dispersion of fugitive emissions. The meteorological parameters to be measured at these levels include hourly mean values of wind speed, wind direction, standard deviation of wind-direction angle, air temperature, and humidity.

Measurements of the wind speed, wind direction, and air temperature in the air layer above the top of the stack must be obtained by remote sensing techniques (pibals, rawinsondes, lidar, radar, acoustic soundings, aircraft, etc.) and should be routinely made at least twice in every 24-hour period (once in the early morning and once in the afternoon). Provision should also be made for

remote sensing at such other times as required by the existence or likely existence of meteorological conditions that are conducive to high ground-level concentrations.

In some instances, it may be possible to utilize the upper-air soundings made twice daily by nearby National Weather Service (NWS) stations to satisfy in part or completely the need for above-stack wind, temperature and humidity measurements. However, if NWS meteorological measurements or other off-site measurements are to be utilized by an operational SCS, such data must be demonstrated by the applicant to be representative of meteorological conditions at the source. In order to demonstrate representativeness, it will probably be necessary for the applicant to make on-site soundings during the background study and to relate these to concurrent NWS soundings.

4.5 METEOROLOGICAL FORECASTING

Many sources utilizing SCS will incur significant time-delays between the control decision and the effect of the decision on air quality. Such facilities will require a meteorological forecasting capability in addition to real-time meteorological and air quality monitoring. Control decisions for such sources in the open-loop mode of operation will require meteorological forecasts in addition to observed meteorological data, and the source will have to begin curtailment activities prior to the onset of the meteorological conditions conducive to high ground-level concentrations.

If the open-loop operational mode fails to anticipate the onset of conditions leading to high ground-level concentrations, the warning provided by the real-time air quality data may be too late to prevent concentrations from exceeding ambient standards.

The meteorological inputs to the operating model are based upon the meteorological elements forecast by the SCS. These elements include, but are not limited to, vertical profiles and time sequences of wind speed, wind direction and temperature from the surface to altitudes of a few thousand feet. The SCS forecasts will require a resolution in time and space not provided by the NWS forecasts.

It is important to note that SCS forecast errors are significant only when they fail to anticipate the onset of adverse dispersion conditions. For example, the NAAQS do not permit the short-term standards to be exceeded more than one time in any given year and, if conditions conducive to high ground-level concentrations occur more than several times per year, a near perfect forecasting capability is required for an SCS to be reliable. Since that degree of forecasting reliability will be difficult to achieve, adequate safety factors must be incorporated into the system.

4.6 DATA STORAGE SYSTEM

The operational SCS must also have a data storage system to document the SCS performance and to permit implementation of the system-upgrade function. Data collection and storage procedures

should be developed during the background study and outlined in the report on that study. Data that must be recorded by the operational SCS and made available to the control agency are listed in Section 2.3.

4.7 SYSTEM UPGRADING PROCEDURES

Upon completion of the background study, the operators of the facility should have a good idea of the capability of the SCS to ensure compliance with ambient standards, and the strengths and weaknesses of the system should be fairly well known. The report on the background study should assess these strengths and weaknesses and should specify additional upgrading procedures that the source will undertake to improve the reliability of the system.

The reliability of an SCS can best be demonstrated by operating the system, including employment of emission curtailments as dictated by the curtailment criteria. Because all types of conditions endangering the ambient air quality standards will not necessarily occur during the period of the background study, the upgrading techniques employed during the background study must be continued, although possibly on a more limited basis, beyond the period of the study in order to improve the reliability of the system.

Additional guidance on SCS reliability assessment and upgrading is presented in "A Technique for Supplementary Control System Reliability Analysis and Upgrading" (EPA, 1976a).

SECTION 5

EVALUATION OF THE OPERATIONAL MANUAL

In addition to the report on the background study, the source must submit an SCS operational manual. Basically, the SCS operational manual is a detailed summary of the specific operational procedures developed during the background study. Thus, some of the same material will be contained in both reports. However, the purposes of the two documents are different. The report on the background study describes the SCS in detail and demonstrates to the control agency the feasibility of maintaining air quality standards by means of SCS. The operational manual states the operational procedures in detail, including procedures to be followed when specific curtailment criteria are met, and specifies the responsibilities of specific company personnel.

The operational manual should include:

- An exact description of the designated liability area
- The number, type and location of ambient air quality monitors in-stack emission monitors and meteorological instruments to be employed in the operational system
- Maintenance and calibration procedures for all SCS equipment
- A description of the meteorological regimes that may lead to ground-level concentrations endangering the short-term air quality standards for SO₂
- The procedures used to determine the existence and to anticipate the onset of those critical meteorological regimes
- A description of the dispersion model or models that account for all meteorological conditions identified during the background study that lead to high ground-level concentrations

- The curtailment criteria used by the source to determine when emission curtailment is required to preclude air quality violations (see Section 2.1 and 2.2)
- The specific actions that will be taken to curtail emissions when the curtailment criteria are met
- A description of alternate procedures to be followed in contingencies such as plant equipment failure, SCS instrumentation failure, plant process problems, or, in the case of power plants, load requirements in excess of those dictated by the SCS
- Identification of the company personnel (names and positions) responsible for initiating and supervising curtailment activities, including names of the individual and alternates responsible for the operation of the SCS and who can apprise the control agency of the status of the SCS at any time
- A description of how the continuous system-upgrade function will be carried out
- Evidence (based on the background study) that the curtailment program will permit attainment of all ambient standards for SO₂

In addition to the above, the following requirements should apply:

- The responsibilities of each individual involved in operation of the SCS should be clearly defined
- From an enforcement standpoint, it is essential that all items in the operational manual that deal with (1) decisions to curtail and resume emissions and (2) the curtailment procedures themselves are as clear and unambiguous as possible.
- Curtailment decisions must be quantitative rather than qualitative and must be based upon the open-loop and closed-loop curtailment criteria specified in the operational manual
- Meteorological, emission and air quality data must be available to the source on a real-time basis
- All requisite data (see Section 2.3) must be recorded and must be available to the control agency; sample formats used to record each type of data should be included in the manual

SECTION 6
ASSESSMENT OF SUPPLEMENTARY CONTROL
SYSTEM ENFORCEMENT PROBLEMS

Sections 3 through 5 have addressed the responsibilities of the cognizant control agency to evaluate applications for SCS. Upon successful completion of the SCS application and development phases, the control agency has the responsibility for surveillance and enforcement of the SCS operation. Additionally, the control agency must conduct periodic reviews of the SCS performance. Those areas of responsibility, briefly discussed in the following paragraphs, are addressed in detail in "Guidelines for Enforcement and Surveillance of Supplementary Control Systems" (EPA, September, 1975).

Regulations will likely require the SCS user to assume responsibility for ambient SO_2 concentrations in a designated liability area and to operate the SCS in strict accordance with the approved operational manual. Compliance with the SO_2 air quality standards within the designated liability area will be largely determined through the air quality monitoring networks operated by the source and the control agency. The control agency should have determined the adequacy of the source's air quality network during its evaluation of the SCS application and background study report. The results of the background study may also aid the control agency in optimizing the location of its own monitors. The control agency should have access to the SCS air quality monitors in order to check their calibration. It is also suggested that the control agency periodically operate its own monitors adjacent to SCS monitors

and compare the simultaneous observations. It is not recommended that the control agency determine compliance solely on the basis of the source's air quality monitoring network. The control agency should operate its own air quality network, even if cost dictates that it be a limited one.

Unless regulations specify otherwise, the source will be required to operate the SCS in strict accordance with an approved operational manual. The manual should stipulate the courses of action to be followed when specified emission curtailment criteria are met (see Sections 2.1 and 2.2). Adherence to an operational manual adds the element of objectivity to the emission curtailment activities and provides a consistent data base (Section 2.3) for periodic system upgrading (Section 2.4).

It should be expected that situations will occur when it will be difficult or impossible for the source to follow normal emission curtailment procedures (for example, during plant equipment failure, SCS instrumentation failure, plant process problems, or, in the case of a power-plant, load requirements in excess of those dictated by the SCS). Enforceable alternate procedures that are to be followed during such contingencies should be stipulated in the SCS operational manual.

One of the basic principles of the SCS concept is that the source should be sufficiently remote from other significant sources such that it can and will accept responsibility for attaining ambient SO_2 standards within a designated liability area. In exceptional cases, if regulations permit, SCS may be feasible in multi-source situations

as long as the sources assume joint responsibility for air quality violations, with predetermined liability apportionment. In multi-source situations, liability for violations must be assumed by the sources because of the difficulty that the control agency would have in quantifying the contribution from each source.

Enforcement of an operational SCS should require that the source keep adequate records (see Section 2.3) so that the cause of an air quality violation can be determined. In addition, since regulations may require that the source comply with the procedures outlined in the operational manual, such records would be needed by the control agency to determine if the source is in compliance with that requirement.

Finally, in order to maintain an effective surveillance and enforcement operation, the control agency must have expertise in air quality and emission monitoring, dispersion modeling, and air pollution engineering. Also, the control agency will require more personnel, equipment, and funds to enforce SCS regulations than to enforce CEC requirements. Thus, it may be appropriate for the agency to impose fees on an SCS source to cover the additional costs of surveillance and enforcement.

SECTION 7

REFERENCES

- American Society of Mechanical Engineers, 1973: Recommended Guide for the Prediction of the Dispersion of Airborne Effluents, Second Edition. ASME Air Pollution Control Division, New York, N. Y.
- Briggs, G. A., 1973: Diffusion Estimates for Small Emissions. ATDL Contribution File No. (Draft) 79, Air Resources Atmospheric Turbulence and Diffusion Laboratories, Oak Ridge, Tennessee.
- Carpenter, S. B., T. L. Montgomery, J. M. Leavitt, W. C. Colbaugh and F. W. Thomas, 1971: Principal Plume Dispersion Models: TVA Power Plants. Journal of the Air Pollution Control Association, 21(8), 491-495.
- Environmental Protection Agency, August 1974: Guidelines for the Interpretation of Air Quality Standards. OAQPS No. 1.2-008, U.S. Environmental Protection Agency, Research Triangle Park, N.C.
- Environmental Protection Agency, September 1975: Guidelines for Enforcement and Surveillance of Supplementary Control Systems, Volumes 1 and 2. EPA-340/1-75-008, U. S. Environmental Protection Agency, Washington, D. C.
- Environmental Protection Agency, October 1975: Guidance for Specifying Primary Standard Conditions under ESECA, OAQPS No. 1.2-035, U. S. Environmental Protection Agency, Research Triangle Park, N. C.
- Environmental Protection Agency, February 18, 1976: Legal Interpretation and Guideline to Implementation of Recent Court Decisions on the Subject of Stack Height Increase as a Means of Meeting Federal Ambient Air Quality Standards, Federal Register, Vol. 41, No. 33, February 18, 1976 (pp. 7450-7452).
- Environmental Protection Agency, 1976a: A Technique for Supplementary Control System Reliability Analysis and Upgrading (in preparation). OAQPS No. 1.2-037, U. S. Environmental Protection Agency, Research Triangle Park, N. C.
- Environmental Protection Agency, 1976b: Guidance for Air Quality Monitoring in the Vicinity of Large Point Sources (in preparation). OAQPS No. 1.2-012, Supplement B, U. S. Environmental Protection Agency, Research Triangle Park, N. C.

Environmental Protection Agency, 1976c: Reviewing New Stationary Sources; Guidelines for Air Quality Maintenance Planning and Analysis, Vol. 10 (in preparation). OAQPS No. 1.2-029, U. S. Environmental Protection Agency, Research Triangle Park, N.C.

Turner, D.B., 1970: Workbook of Atmospheric Dispersion Estimates (revised). Office of Air Programs Publication No. AP-26, U.S. Environmental Protection Agency, Research Triangle Park, N.C.

APPENDIX A
METEOROLOGICAL CONDITIONS AND OTHER FACTORS
CONDUCTIVE TO HIGH GROUND-LEVEL
CONCENTRATIONS

Essential to the development and operation of a reliable SCS is an adequate knowledge of the meteorological conditions and other factors most likely to result in ground-level concentrations that endanger ambient air quality standards for SO_2 . The effects of these factors are a function of source characteristics.

A.1 FACTORS LEADING TO HIGH GROUND-LEVEL CONCENTRATIONS FROM STACK EMISSIONS

The meteorological conditions most likely to lead to high ground-level concentrations from stack emissions are:

- Looping plume
- Inversion breakup (fumigation)
- Neutral stability in combination with moderate to high wind-speeds
- Limited mixing

Other factors that may lead to high ground-level concentrations from stack emissions are:

- Building wakes
- Terrain effects

Building-wake effects are generally of concern only in the presence of moderate or strong winds. Terrain effects can occur under a wide range of stability and wind-speed conditions.

The behavior of stack plumes under the above conditions is summarized below. Mathematical formulas for estimating ground-level concentrations under some or all of these conditions are given by Turner (1970), Carpenter, et al. (1971), Briggs (1973) and in "Reviewing New Stationary Sources" (EPA, 1976c).

A.1.1. Meteorological Conditions

Looping Plume

This situation is usually observed on warm days with clear skies and low to moderate wind speeds. The vertical temperature structure is unstable, creating large thermally-induced eddies that cause the plume to impact at ground level close to the source. This condition can persist for most of the daylight hours, but due to the variable nature of a looping plume, any specific receptor site will be affected for only a fraction of that time. Thus, looping is of greatest concern with respect to compliance with very short term air quality standards defined for averaging times of one hour or less.

Inversion Breakup (Fumigation)

The behavior of stack plumes and the meteorological structure associated with the breakup of nocturnal ground-based radiation inversions is shown schematically in Figure A-1. Conditions during the early morning hours shortly after sunrise are shown in Figure A-1a. The surface-based temperature inversion (temperature increases with height) that typically forms over land surfaces at night in fair-weather light-wind regimes has begun to dissipate, but the stack plume is still contained in a thermally stable layer. Under these conditions, the stack plume remains aloft and does not mix to the ground. Concentrations

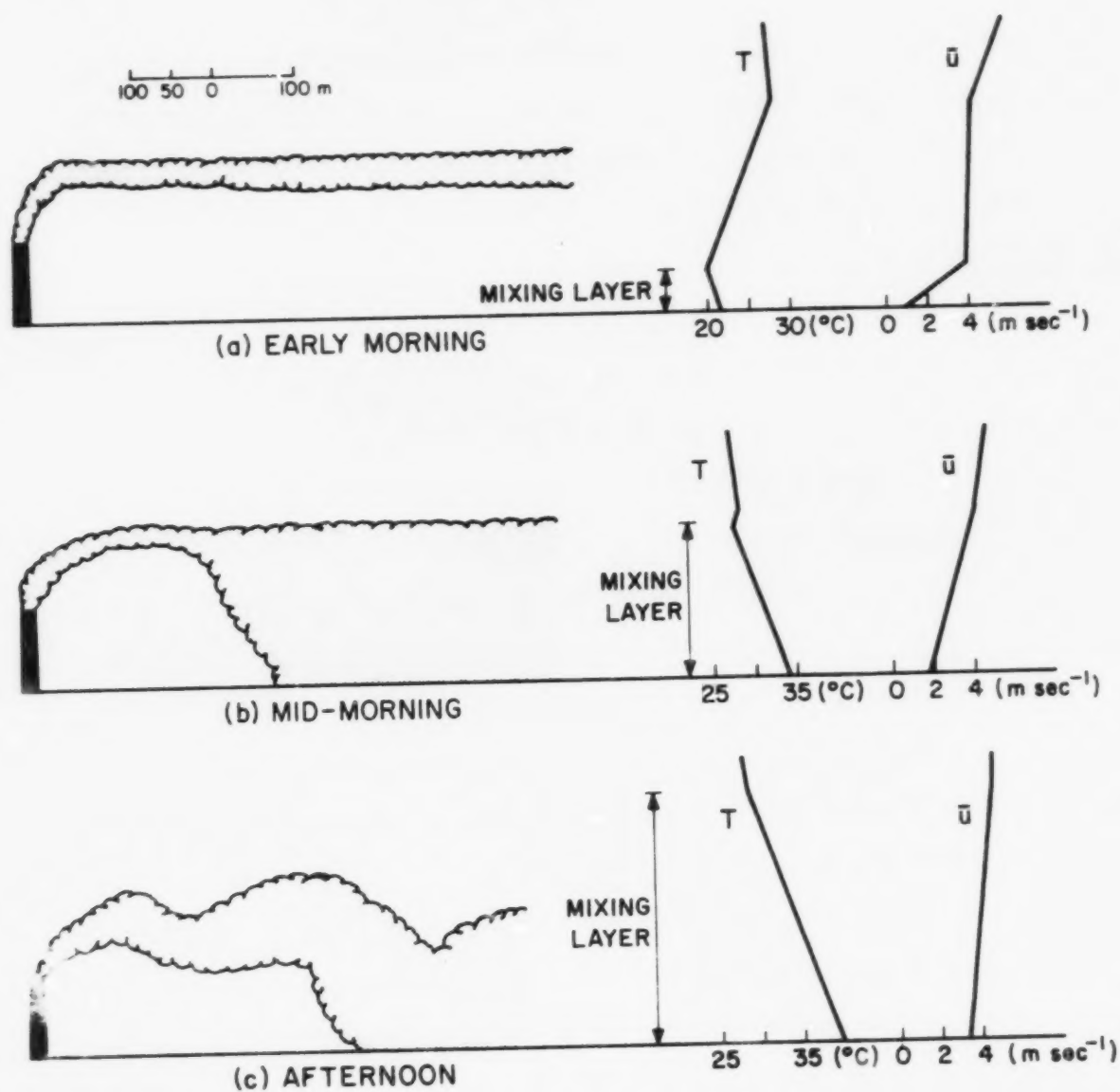


FIGURE A-1. Schematic diagram of the fumigation process, including vertical profiles of temperature (T) and wind speed ($\bar{u}$).

within the plume are high, as shown by the small plume dimensions, because of the very limited turbulent mixing. The shallow thermally-unstable layer (temperature decreases with height) near the ground is called the surface mixing layer. As the heating of the ground surface by solar radiation proceeds, the depth of the surface mixing layer increases. Figure A-1b shows that when the top of the mixing layer reaches the height of the stack plume the pollutants contained in the plume are suddenly brought to the ground. This process, which is called fumigation, produces very high ground-level concentrations that typically persist for 10 to 30 minutes. Fumigation is a transient phenomenon and the high initial ground-level pollutant concentrations decrease as the depth of the surface mixing layer increases and turbulent mixing acts to spread the pollutants over the entire depth of the layer. Figure A-1c shows the stack plume at a later time when the mixing layer extends well above the plume stabilization height and the ground-level pollutant concentrations are controlled by turbulent mixing processes.

Fumigation is clearly of greatest concern with respect to compliance with very short-term air quality standards defined for averaging times of one hour or less. It is generally of lesser concern with respect to compliance with the 3-hour NAAQS for SO_2 , especially when the surface mixing layer extends well above the plume stabilization height. However, fumigation tends to produce high ground-level concentrations for relatively long distances downwind from the stack because of the high concentrations in the plume prior to the onset of fumigation. For this reason, and also because it is difficult to predict with

acceptable certainty the onset time of fumigation, sources for which fumigation may lead to violations of short-term air quality standards should routinely curtail emissions several hours before fumigation can reasonably be expected to occur.

Neutral Stability in Combination with Moderate to High Wind Speeds

Maximum ground-level concentrations resulting from buoyant stack emissions, in the absence of fumigation or other special conditions, generally occur under neutral stability when the mean wind speed at the plume stabilization height reaches a certain value called the critical wind speed. The critical wind speed is determined principally by the heat content of the stack discharge and the height of the stack. Figure A-2a shows the behavior of a stack plume for the critical wind speed condition (also called the critical coning condition). If an elevated inversion lid (base of an elevated thermally-stable layer) is located just above the plume stabilization height, the vertical growth of the stack plume will be restricted and this may produce an increase in the maximum ground-level concentration for the critical wind-speed condition. Relatively large departures of the wind speed from the critical wind speed produce relatively small decreases in the maximum ground-level concentration. For example, mean wind speeds that differ from the critical wind speed by a factor of two may cause only a 10 percent reduction in the maximum ground-level concentrations calculated for the critical wind speed.

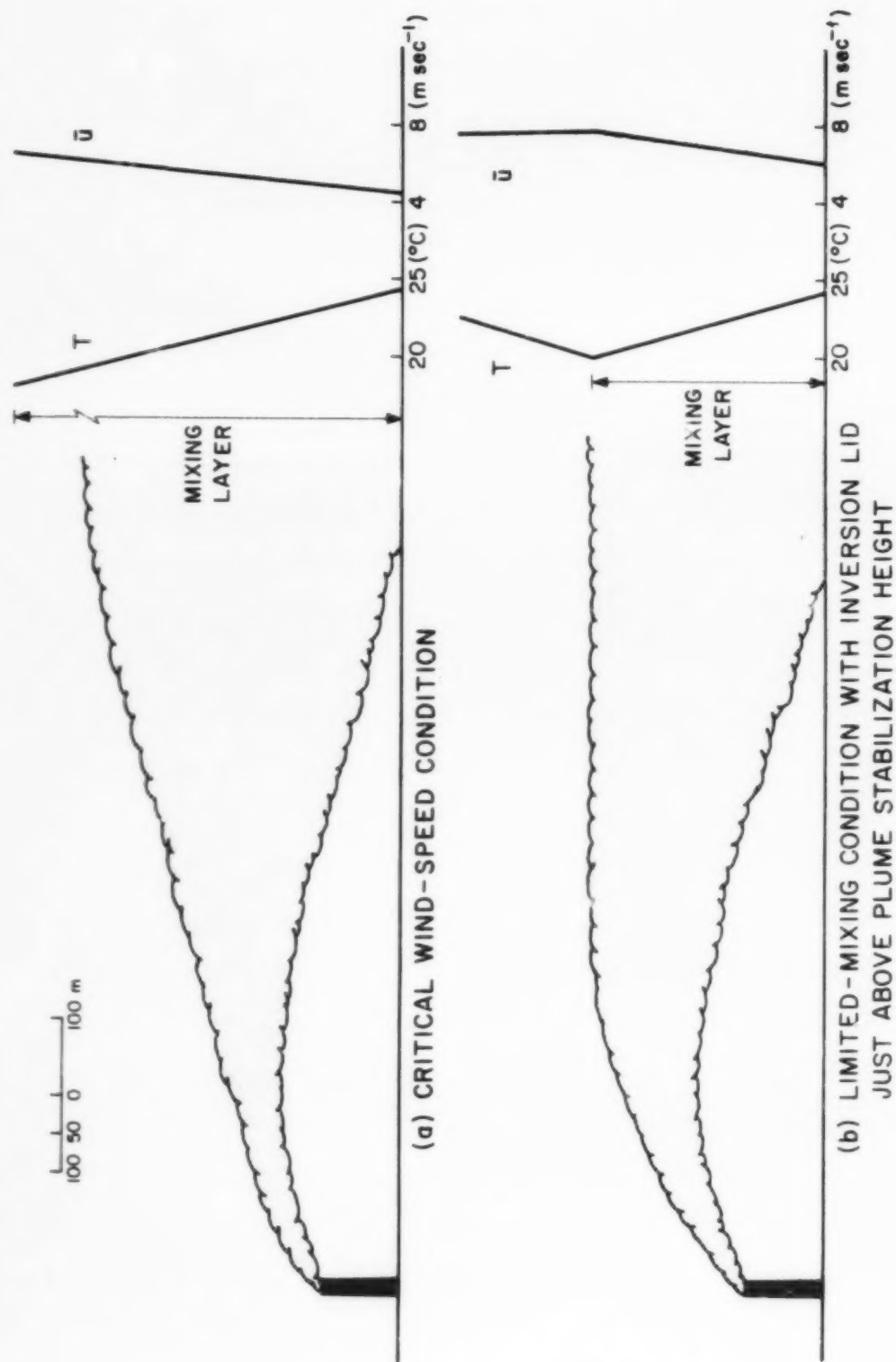


FIGURE A-2. Plume behavior for the critical wind-speed condition (a) without and (b) with the presence of an elevated inversion lid.

Limited Mixing

The presence of an elevated inversion base above the plume stabilization height restricts the vertical growth of the stack plume and thus results in higher ground-level concentrations than would occur in the absence of such a restriction. As mentioned above, if the height of the elevated inversion base is just above the plume stabilization height, the maximum ground-level concentration is increased. Additionally, two processes act to produce higher ground-level concentrations than would otherwise occur at downwind distances beyond the point of the maximum ground-level concentration. First, further vertical plume growth is prevented by the inversion lid. Second, as the result of the turbulent mixing of the plume within the layer below the inversion lid, the concentration of pollutants tends to become uniform along the vertical. This results in a relative decrease of pollutant concentration near the plume stabilization height and a relative increase at ground-level. The vertical restriction of plume growth during the limited-mixing condition is shown in Figure A-2b.

A.1.2 Building and Terrain Effects

Building Wakes

In the presence of moderate and high wind speeds, the dispersion of stack plumes may be adversely affected by aerodynamic wakes formed in the lee of tall buildings or other obstacles. As pointed out in the general discussion of aerodynamic wake effects on plume dispersion in the ASME Guide (1973), plumes emitted from stacks less than one building height above the tops of adjacent buildings are likely to be caught in the building-wake cavity circulations and brought quickly to

the ground. Plumes emitted from stacks extending between one and two building heights above a nearby building may be caught in a region of disturbed (displacement) flow which can limit the buoyant rise and bring the plume to the ground somewhat sooner than would otherwise occur. Figure A-3 shows the airflow pattern about a cubical building during moderate to strong winds.

The most obvious consequence of building wakes is to cause higher ground-level concentrations than would otherwise occur. A rough rule-of-thumb is that adverse building-wake effects extend up to 2 1/2 times the building height and downwind to a distance of 10 building heights. Thus, building-wake effects can be largely avoided if the tops of the facility stacks are outside that adverse zone of influence. If this condition is not satisfied, plume dispersion calculations that do not take building-wake effects into account may very seriously underestimate the maximum short-term ground-level concentrations that will actually occur with moderate to strong winds. As a part of their justification for use of SCS, applicants should be required to include scale drawings showing stack and building locations, building dimensions and ground elevation contours. The effects of building wakes on plume dispersion and simplified methods for estimating ground-level concentrations are described by Briggs (1973).

It should be noted that the general rules-of-thumb for wake effects given in the ASME Guide (1973) cannot be expected to apply in every case, and each source should be evaluated by a qualified

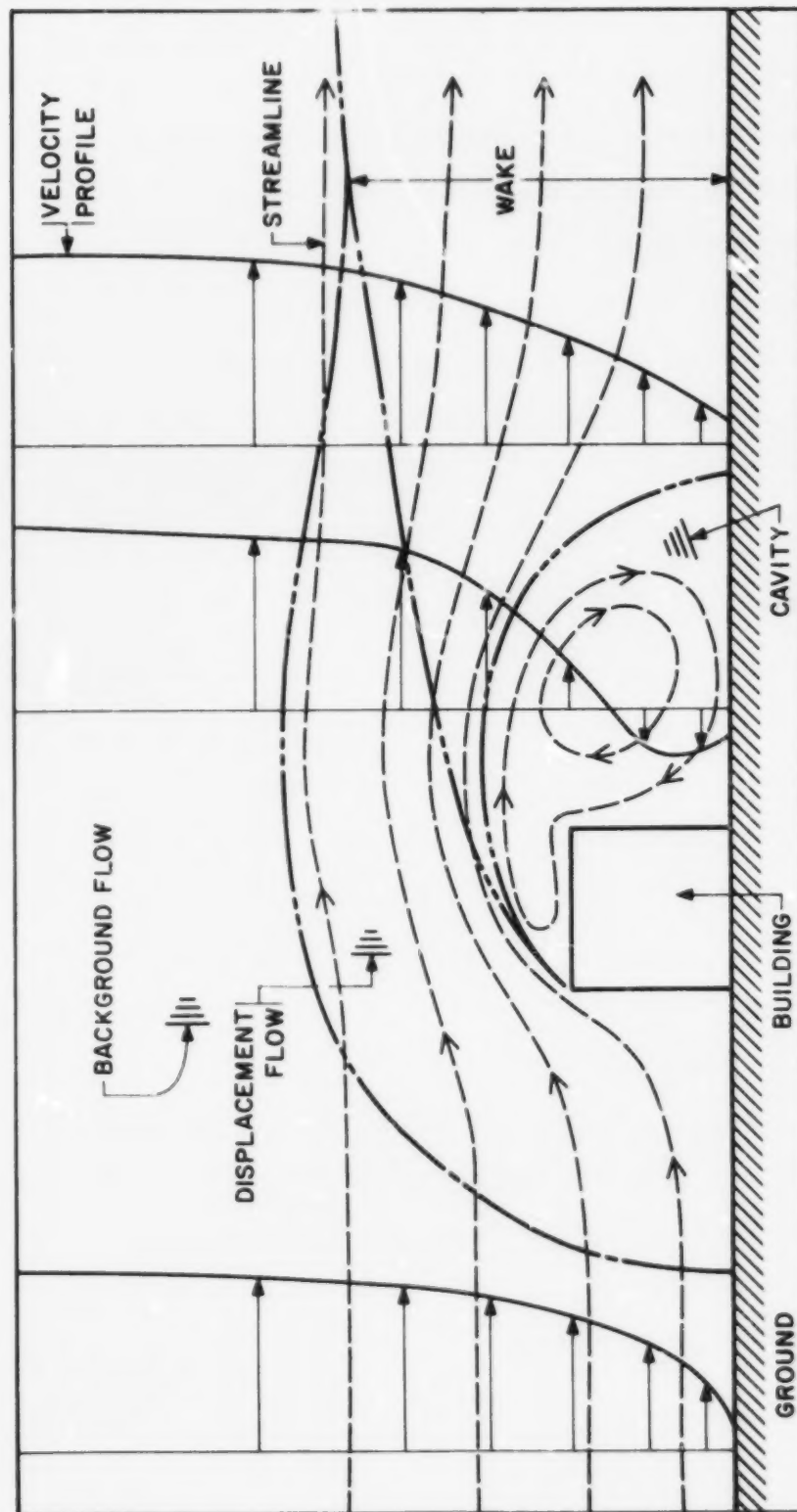


FIGURE A-3. Mean air flow about a cubical building (reproduced from ASME, 1973 by permission of the American Society of Mechanical Engineers).

meteorologist. The potential for building wake effects may be determined by visual observation of plume behavior over a sufficient period of time, by tracer releases or by wind tunnel studies.

Terrain Effects

There are two principal terrain effects that may produce ground-level concentrations of stack emissions that exceed the maximums predicted by the conventional dispersion model formulas for fumigation, critical wind-speed and limited-mixing conditions in which flat terrain is assumed. These terrain effects are:

- Aerodynamic downdrafts in the lee of prominent terrain features during moderate and strong winds
- Increases in terrain elevations along the downwind plume trajectory that significantly reduce or eliminate the height of the plume axis above the ground surface

The essential features of the disturbed air flow in the lee of terrain obstacles during moderate and strong winds are qualitatively very similar to those shown in Figure A-3. Plume downdrafts occur whenever the plume enters either the lee-vortex (cavity) or displacement-zone circulations. Significant terrain features located near the stack thus have effects on plume dispersion similar to the effects due to plant buildings or other structures. Potentially serious aerodynamic downdraft problems exist whenever the stack height is below or approximately equal to the maximum terrain elevation. Aerodynamic downdrafts may also occur downwind from the stack where the plume passes over a ridge or other elevated terrain feature.

Plume behavior in rugged or mountainous terrain is in general not well documented, and accurate calculations of pollutant concentrations at air-terrain interfaces on the sides or tops of mountains are generally not possible. Air quality monitoring is currently the only reliable method of evaluating the magnitude of terrain effects for sources located in complex terrain.

Visual Evidence of Building or Terrain Effects

Relatively simple observations often can give evidence of the presence of adverse or potentially adverse building or terrain effects. The following questions should be considered in evaluating an individual source for the possibility of wake or terrain effects:

1. Has the plume centerline been observed to slope downward instead of horizontally or upward (evidence of downdrafts or wake effects)? If so, under what meteorological conditions has this behavior been observed? Is there a preferred direction for this behavior?
2. Are the top few feet of the outside of the stack blackened by soot (evidence of downdrafts or wake effects)?
3. Does the plume often fail to rise significantly, even under light wind conditions (evidence of downdrafts or wake effects, low effluent momentum and/or buoyancy, or a combination of these factors)?
4. Are there any significant hills, valleys, rivers or lakes within a few miles of the source that might affect the plume dispersion?
5. Has the plume been observed to drift into, or appear to

be trapped against, a hillside (evidence that the plume centerline may approach the elevated terrain, leading to high concentrations)? If so, where, when and under what meteorological conditions has this behavior been observed?

6. Has the plume exhibited any other behavior that could affect ground-level concentrations?

A.2 FACTORS LEADING TO HIGH GROUND-LEVEL CONCENTRATIONS FROM LOW-LEVEL OR FUGITIVE EMISSIONS

Fugitive emissions, frequently a problem at certain sources (e.g., nonferrous smelters), are discharges to the atmosphere from plant buildings, roof vents, or other low-level exit points. Such emissions, because of their low release heights, have a relatively large impact on air quality and may lead to air quality violations alone or in combination with stack emissions. Thus, to insure against air quality violations and to minimize the required frequency of stack emission curtailments, fugitive emissions should be captured and vented into stacks.

Because fugitive emissions typically have little thermal buoyancy and frequently enter the building cavity circulations, they are best classified as surface-based volume sources. Fugitive emissions are thus most likely to adversely affect ambient air quality in the vicinity of the source during persistent light-wind and poor dispersion conditions. These conditions typically occur at night and in the early morning during fair weather with light gradient winds.

In most cases, steps may be taken to significantly reduce or effectively eliminate fugitive emissions by sealing leaks and by capturing emissions at all stages of production and discharging them through existing stacks. As a part of the implementation of an SCS, the source should be required to present a comprehensive inventory of all low-level fugitive emissions and to show that these emissions do not endanger the ambient air quality standards. Procedures for estimating ground-level concentrations arising from low-level fugitive emissions are given by Briggs (1973).

APPENDIX B

ITEMS TO BE INCLUDED IN SUPPLEMENTARY CONTROL SYSTEM APPLICATION AND BACKGROUND STUDY REPORT

Sources proposing to use SCS generally must submit three reports to the responsible control agency. In the first report, the application to use SCS, the source must (1) demonstrate that SCS is needed as a control measure if ambient standards for SO_2 are to be met in the vicinity of the source, (2) propose an SCS design concept and (3) provide evidence that use of the proposed system would ensure the attainment of the ambient SO_2 standards. Although the specific outline for the application may vary from case to case, the items listed in Section B.1 should be addressed in all applications to use SCS.

Upon control agency approval of the application, the source must conduct a background study, which includes a field monitoring program, to develop an operational SCS. A report on this background study, demonstrating that the operational SCS will maintain the air quality standards, must then be submitted to the control agency. Section B.2 provides a list of the items that should be included in the report on the background study.

In addition to the report on the background study, the source must submit an SCS operational manual for approval. Basic requirements for the operational manual are outlined in Section 5.

B.1 APPLICATION

1. Justification for the source's application to use SCS; viz. a demonstration that SCS is needed as a control measure at the source in question if ambient standards for SO_2 are to be attained.

2. Description of the type, location and age of the facility, including:

- A description of the processes, equipment, raw materials and/or fuels used by the facility
- Stack heights, exit velocities, volumetric flow rates, stack gas exit temperatures and pollutant emission rates.
- Scaled plan layouts, including horizontal and vertical dimensions of all structures within a 10 stack-height radius of emission points
- A topographic map of the plant property and surrounding area

3. Evidence that the source qualifies as an isolated source and an exact description of the designated liability area (DLA) in which the facility proposes to accept legal responsibility for meeting ambient SO_2 standards (see Section 3.2).

4. Number, location and relevant emission inventory of sources in the vicinity of the proposed DLA.

5. Data on the frequency and severity of recent ambient SO_2 concentrations in excess of the ambient standards, together with supporting emission and meteorological data, if available.

6. A complete description of the source's constant emission control (CEC) techniques including:

- A description of CEC techniques that are currently in use and the resulting emission rate

- A description of any additional CEC techniques that will be employed, the proposed schedule for implementing these measures, and the emission rate that will be achieved upon implementation
 - Emission standards, if any, that will apply to the source and evidence that these emission limitations will be met
 - A description of the source's current fugitive emissions (if any), an assessment of the impact of those emissions on ambient air quality and the source's plans to control fugitive emissions
7. A preliminary demonstration of the feasibility of attaining ambient SO_2 standards through the use of SCS, including:
- Estimates of the response times required by the source to achieve various degrees of emission curtailment and a description of the procedures to be employed to curtail emissions
 - Estimates of the advance warning times that the SCS will provide regarding adverse atmospheric dispersion conditions
 - A listing of all parameters necessary for dispersion modeling, including stack and building locations and dimensions, total volumetric emission rates, stack gas temperatures, stack gas exit velocities and pollutant emission rates
 - Dispersion model calculations of maximum concentrations for the averaging times of the applicable ambient SO_2 standards for (1) emission rates resulting from existing and planned CEC and (2) emission rates resulting from the projected CEC in combination with the proposed SCS (the latter calculations should show the facility to be in compliance with all air quality standards for SO_2)
8. The source's plan for the development of the proposed SCS to include:
- A description of all air quality, emission monitoring and meteorological equipment to be used
 - A description of the method that will be used to determine emission rates
 - Names and qualifications of key personnel responsible for the development of the SCS (the guidance of an experienced meteorologist with a background in dispersion modeling is clearly required during the design, data collection and analysis phases of the SCS development)

- A description of the general plan of investigation to be followed during the background study to develop the SCS operational procedures
- 9. Any other factors deemed pertinent by the source in justifying the use of SCS.
- 10. Any additional information that regulations require from the source to justify the use of SCS

B.2 BACKGROUND STUDY REPORT

1. Names and qualifications of all key personnel involved in the background study (resumes should indicate adequate experience in air quality monitoring, dispersion modeling, air pollution engineering and the analysis of field data).
2. A description of the air quality monitoring network to include:
 - An exact description of the DLA
 - Type or types of monitors, calibration procedures and procedures for obtaining, recording and analyzing data
 - Number of monitors, locations of monitors at the start of the study, and rationale for the initial placement of monitors
 - Details of monitoring program conducted during the background study (including the use of mobile and portable monitors)
 - Basis of the finalized locations of the monitors and assessment of the probability that the air quality network will observe air quality violations
3. A description of the emission monitoring system to include:
 - Number and type of in-stack monitors, calibration procedures, and procedures for obtaining and recording data
 - Proof that material balance or process calculations provide data equivalent to in-stack monitors (if the operational SCS proposes to use such calculations rather than in-stack monitoring)

- An assessment of the uncertainties in real-time emission estimates
4. A description of the meteorological system to include:
 - Number, type and location of all meteorological instruments
 - Calibration procedures and procedures for obtaining, analyzing and recording data
 - Evidence that these data are representative of the conditions affecting the dispersion of emissions from the source
 - A description of the source's meteorological forecasting program
 5. A description of the dispersion model or models to be used in the open-loop SCS operational mode, including:
 - An explanation of all model equations and input parameters
 - An explanation of the basis of model selection
 - The concentration averaging time of the model or models
 - A comparison of maximum observed and calculated ground-level concentrations for all periods during which simultaneous emission, meteorological and air quality data were collected
 - An assessment of the accuracy of the model or models, based on the above calculations
 6. A description of the method used to vary the emission rate, to include:
 - An explanation of why this method was selected
 - An estimate of the time-response curve for emission reduction
 - An estimate of the accuracy of emission projections based on this response curve
 - A tabulation of all emission curtailments employed during the background study, including the curtailment criteria that applied in each case
 7. A description of the SCS operational procedures developed during the background study, including:

- The SCS threshold concentrations (see Sections 2.1 and 2.2) for the open and closed-loop modes of system operation, and the corresponding degrees of required emission curtailment
- The specific manner in which the threshold concentrations were derived
- A description of the critical meteorological conditions (see Section 2.1), the meteorological criteria used by the operating model to identify each critical condition, and the corresponding degrees of required emission curtailment
- The criteria used by the operating model (Section 2.1) to predict the occurrence of critical meteorological conditions
- The specific manner in which the critical meteorological conditions were identified
- An estimate of the annual number of occurrences of each critical condition as well as the periods (time of day and time of year) when each condition is most likely to occur
- An estimate of the percent of the time that emission curtailment will be required under the operational SCS
- The data storage procedures
- The system upgrade procedures

8. Evidence that the procedures outlined for the operational SCS: (1) would have precluded all air quality violations if they had been employed during the background study, and (2) will prevent violations in the future (this analysis must include the effects of time delays in emission curtailment and downwind transport of pollutants).

9. A summary of the air quality, emission and meteorological data gathered during the field study that is sufficient for the control agency to independently verify any of the major conclusions of the study.